Evolutionary Computation III
Sex, Mind and Language

Overview

- What is sex for?
- Mind: the adaptationist perspective
- Language: origins and evolution

Background for this week's lecture:

Barkow, J.H., Cosmides, L & Tooby, J. (1992). *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*. Oxford University Press. Especially Chapter 2, by D. Symons, On the Use and Misuse of Darwinism in the Study of Human Behavior. pages 19-136.

Diamond, J. (1997). *Why is sex fun? The evolution of human sexuality*. Phoenix.

Hurford, J.R., Studdert-Kennedy, M. and Knight, C. (1998). *Approaches to the Evolution of Language*. Cambridge University Press. See also papers from the bi-annual Evolution of Language Conferences (last one was Evolang 2000, in Paris April 2000).

Ridley, M. *The Red Queen: Sex and the evolution of human nature*. Penguin Books 1993.

The Adapted Mind and Evidence for it

Darwin answered the age-old question:
"Why are people?" (Dawkins, 1976 quoted in Symons)

but once we know why people are, we want to know
"What of it?" (Medawar, 1982 quoted in Symons)

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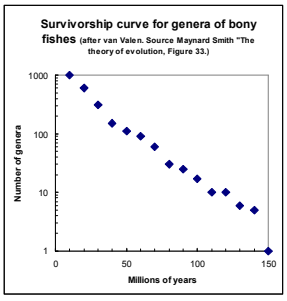
About 30 years ago, influential biologists changed their ideas about sex: *"Sex is not about reproduction, gender is not about males and females, courtship is not about persuasion, fashion is not about beauty, and love is not about affection".* (Ridley, p. 26-7).

Evolution is not about progress:
evolution is a treadmill, not a ladder.

The Red Queen Hypothesis (Van Valen)

- The Red Queen, in "Alice in Wonderland", explained to Alice that it takes all the running you can do to stay in the same place.
- In evolution (the hypothesis goes) species are engaged in an evolutionary race, and advances by one group result in deterioration of the environment (or fitness) for others.
- Examples include hosts and diseases, s.a., malaria and human adaptation to it, and predator and prey techniques s.a., moth flight and bat sonar.

Evolution doesn't care about extinctions



Note that the y-axis is log scale

What is sex for? But more importantly Why sex?

(This section is mostly from Ridley, p.26 ff)

- Asexual reproduction can produce twice as many offspring as sexual reproduction
  - Plants and animals would apparently be better off breeding asexually.
  - the problem is that many plants and animals seem unaware of the conclusion.
- Why must a baby be the product of two parents? Why not one, or three? Need there be a reason at all?
  - Microscopic animals split in two
  - Willow trees grow from cuttings
  - Dandelions produce seeds that are clones of themselves.
  - Virgin greenflies give birth to virgin young that are already pregnant with other virgins.
    - Greenflies reproduce asexually all summer, then in the last generation, give birth to males and females that mate once, and the eggs lie on the bottom of the pond until the next spring
  - Some fungi have 10,000 different sexes
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Sex (biologists agree) is about genetic mixing

- Biologists agree that sex is about genetic mixing, but they disagree about why *genetic mixing* is a good idea.
- Some ideas that **don't** work:
  1. Sex is a free trade in good genetic inventions, and thus greatly increases the chances that good inventions will spread through the population (true).
  2. Genetic variability speeds up evolution (true).
     - Both (1) and (2) are true, but neither constitute a *reason* for sex. They are merely an additional benefit after it has been invented. This is because evolution is directionless. The coelacanth (a fish that lives off madagascar) has been the same for 300 million years.
     - The mathematics of genetics shows that mutations can come together in sexual species, and not asexual ones. But it still doesn't constitute a reason for investing half the population of a species in each of two sexes. The flaw in the logic is that in asexual species don't care about the future. If they out evolve a sexual species for a thousand years, then due to their lack of variability they go extinct, that's just life.
  3. The struggle for existence is between species, and species are selected for based on what is good for the species (false).
     - The flaw in group selection arguments is that individuals don't do things for the good of the species, only for the good of themselves and their offspring. That may coincidently be good for the species, but evolution is a blind watchmaker.

Why is genetic mixing a good idea?

- Why swap genes?
  - To generate diversity. Individuals have a better chance of at least some of their offspring surviving if their genes are paired up in lots of different ways. With predators (like bacteria that reproduce as fast as 10 mins per generation) swapping genes is the fastest way to introduce variability into a population. Recombination drives evolution, rather than mutation.
- Why 2 sexes?
  - Reservoir of variability: mutation is very slow. Repair spares for damaged genes. An individual differs from their parents in just a few genes due to mutation, which may have no functional consequences. But those mutations would accumulate and destroy any complex structure over evolutionary time.

What are typical lifestyles that enable a species to effectively swap genes?

- Typical sex lives
  - For the 4300 mammal species:
    - adult males and females are solitary and meet only to copulate.
    - Males do not provide parental care.
  - For the social mammal species (lions, wolves, chimps, and hoofed mammals):
    - Adult males do not favour their own over others in the herd/tribe.
    - Sex is carried out in public.
    - Ovulation is advertised by visual cues, smell and behaviour.
- Atypical sex lives
  - Mammals which have paternal care:
    - include polygynous groups (zebras, gorillas with harems);
    - solitary couples (gibbons);
    - Polyandrous females (saddleback tamarin monkeys have two adult males to one female)
  - Mammals who practice sex for fun:
    - (bonobos and dophins). Sex is public.
  - Menopause is rare.

The animal with the weirdest sex life

- Long term pair bonds with repeated sex mainly or exclusively with each other
- Partnership for joint rearing of resulting babies, including male parental care
- Couples live in a society of other couples with shared access to communal territory
- Sex in private
- Human ovulation is concealed. Most human sex is for fun, not for insemination
- All females who live past 50 undergo menopause – a complete shutdown of fertility.

Computational models

- Evolutionary computation has many models for selection of generations, including (from M. Mitchell)
  - Roulette wheel
  - Tournament selection
  - Rank
  - Stochastic selection
  - Steady state
- Many variations can be used. The computational consequences are varied, and simplistic thinking about modeling needs to be cached out in actual simulations.

Mind: the adaptationist perspective

- Evolutionary survival or advantage underpins every aspect of bodies.
- The adaptationist perspective says that it underpins every aspect of behaviour and mind as well.
- However, just as bodies are made of component organs each tailored to a specific situation, so behaviour and mind have modules that are tailored to specific situations.
- It is not possible to create a science of human behaviour based on analysis of reproductive consequences of human action. No general reproduction-maximization organ exists, only a bunch of specific ones.
- Therefore, to understand human behaviour and mind, you need to understand the modules and their adaptations that comprise it.

The adaptationist perspective focuses on explaining different aspects of being human

from Kaplan (in Barkow p. 581 ff)

- Consider two alien anthropologists studying h. sapiens:
  - One might emphasize themes of
    - Sexuality
    - Warfare
    - Deception
  - The other might emphasize h. sapiens as a
    - Processors of information
    - Builders of knowledge structures
  - What they observe will affect what they study. The rational view of cognitive science focuses on cognition, such as attention, memory, learning and limited processing capacity. The adaptationist view focuses on affect (how people feel about things, rather than what they think about them).

Kaplan's matrix

		Content emphasis	
		Affect	Cognition
Basis of explanation	Evolution	Sociobiology	
	Information processing		Cognitive Science

The adaptationist perspective views mind as a set of "adaptations" supported by modules

- "The human brain/mind is an integrated bundle of complex mechanisms (*adaptations*). Each mechanism was designed by natural selection in past environments to promote the survival of the genes that directed its construction *by serving some specific function* – i.e., by performing some specific task, such as regulating blood pressure, perceiving edges, or detecting cheaters in social exchanges." (Symons in Barkow, p. 138.)
  - e.g., Sugar: tastes sweet, and the goal of experiencing sweetness motivates behaviour
- "The adaptationist question "what is the function of a given structure or organ?" has been for centuries the basis of every advance in physiology." (Mayr 93 in Symons p. 140)
- Evolution by natural selection accounts for the origin and maintenance of adaptations.

Computational models

- Modularity vs. general purpose mechanisms are surprisingly hard to test computationally.
- ???

Language: Origins and Evolution Issues

- Why did language evolve (in humans and not other species)?
- What properties do non-human communication systems share with the human language faculty?
- When did language evolve?
  - Origin of phonetic abilities
  - Origin of syntax
  - Origin of symbolic representation of semantic abilities
- How did language evolve? (what were the dynamics of language evolution)
  - Evolution of phonetic systems
  - Evolution of the lexicon
  - Evolution of grammatical structures

Sources of evidence

"Human language is an embarrassment for evolutionary theory"

D. Premack

- Language leaves no direct fossils. No volcanic ash has preserved a primitive noun clause. No footprints of an ancestral verb wait to be unearthed in a remote archaeological dig. At least, not literally. How then can the origins and evolution of language be (scientifically) explored?
- Many scientists including linguists, computer scientists, anthropologists, paleontologists, ethologists, geneticists, and neuroscientists are concerned with the origin and evolution of language.
- Major areas represented at Evolang conferences include:
  - Primate research: Language capabilities of the great apes (de Waal, Tomasello, Savage-Rumbaugh)
  - Linguistics: e.g., Evolution of grammar in sign languages (Senghas); cross cultural studies
  - Anthropology: evidence from tools and cultural artifacts, distribution of cultures worldwide
  - Computational models: simulations of language as systems (macro-models) or simulation of utterance exchanges (micro-models), varying from the abstract with no specific human language analog to the detailed simulation of a specific language able to make direct predictions about that one language.

Computational models of language evolution

- Computational models are mostly in the areas of the dynamics of language evolution and change.
- They have little (if anything) to say about the origins of language.
- They can be abstract about generic properties of language as communication, or specific to human language, based on human data and aiming to predict properties of human language:

Computational models

- Macro-models: Properties of language as a system.
- Predictive models:
  - Syntactic communication (Nowak, Plotkin and Jansen)
- Generic properties:
  - Hurford
- Micro-models: Modelling individual communciations
- Predictive models:
  - Hare and Elman – language change
- Generic properties:
  - Kirby – coherence of languages
  - Hurford – dynamical properties of language
  - Tonkes – evolution of learner friendly languages
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Caveat Emptor: The role and limitations of modeling

- What can models show?
- What can't they show?

Problems with claims about simulations

It is not valid reasoning to conclude
anything about the biological world *on*
the basis of computational simulation alone.

- This doesn't mean that simulation is not a powerful tool. Just that not all the answers we seek can be gained from simulations alone.
  - Simulations can provide
    - a test of reasoning,
    - converging evidence,
    - or make the modeler cash out (specify) all the components of a model.
  - Unexpected behaviour in the simulations can suggest hypotheses to raise about real world systems.
- They cannot, on their own, allow one to *conclude* anything about the real world.

Caveat Emptor: The role and limitations of modeling

- Some incorrect claims
- In the Baldwin simulations, we have shown that learning can guide evolution in the sense that abilities that are learned in the individual early in the simulation become canalised and are eventually genetically specified in subsequent generations. This shows that the Baldwin effect is a major factor in biological evolution.
- In simulation, we have shown that language requires a learning bottleneck for generalization to evolve reliably. This shows that parents teaching children language is a major factor in the evolution of human syntax.
- Corrected version of the above claim:
- In simulation, we have shown that under certain conditions, a learning bottleneck facilitates the evolution of reliable generalization, whereas simulated evolution of languages without such a bottleneck does not. These results raise the potential that the learning bottleneck posed by children's acquisition of language plays a functional role in the structure of human languages. Such an idea needs to be tested empirically